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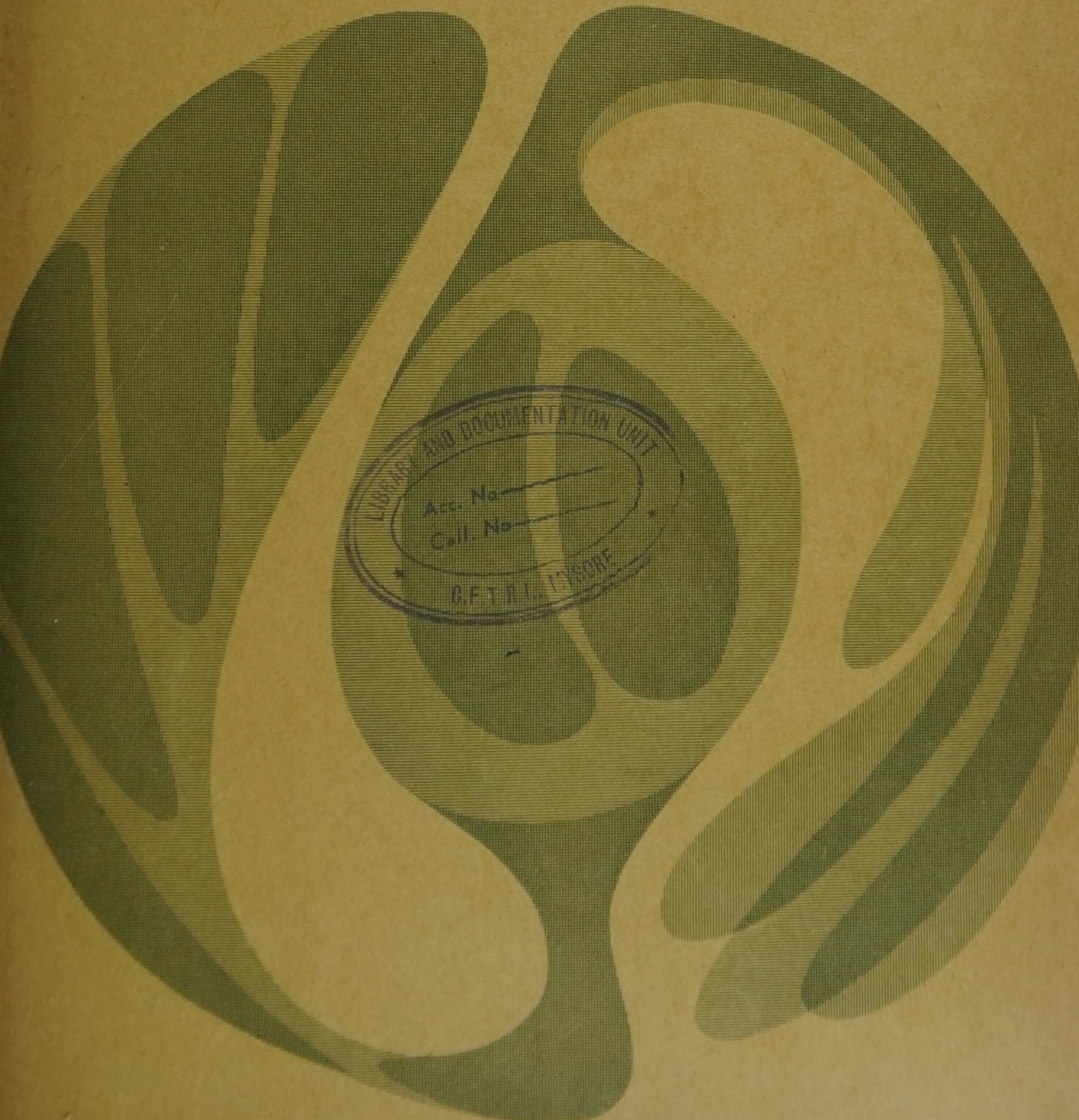
G 49 Particle boards from Cyprus-grown trees



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Tropical Products Institute Report

G 49

Particle boards from Cyprus-grown trees

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Particle boards from Cyprus-grown trees

INTRODUCTION

Following a visit to the Republic of Cyprus by a member of staff of the Tropical Products Institute, a request was received from the Forests Department of the Ministry of Agriculture and Natural Resources, to examine the wood from seven different species of locally-grown trees and assess the suitability of the wood for use in the manufacture of particle boards.

Description of samples

The samples consisted of debarked logs, 4 to 6 feet in length and 3 to 19 inches in diameter, which were described by the Acting Director of the Department of Forests, as:

a. *Pinus brutia,* from the crown of an over mature tree, from the trunk of an old tree and some branches. About 60 tons is available on site daily and of this weight about half is sawmill waste and the remainder 'tops' and branches which are unsuitable for sawmilling.

b. *Pinus nigra,* from the crowns of both an old and a young tree, some resinous heartwood and a number of branches. 3½ tons are available daily, one third in the form of sawmill waste and the rest from 'tops' and branches.

c. *Acacia cyanophylla,* from coppice; about 3½ tons are available daily for board-making.

d. *Quercus alnifolia,* about 2 tons are available for boardmaking daily.

e. *Alnus orientalis,* about ¾ ton available daily.

f. *Eucalyptus gomphocephala* and *Eucalyptus camaldulensis,* used at present exclusively in Cyprus for the production of parquet flooring but these species were included since a knowledge of their board-making properties may well be of use in the future.

Preparation of samples

Each sample was examined separately for its boardmaking possibilities and so that the results could be compared, the method of preparation of each sample was identical. The logs were cut into billets 10 inches long and placed in a soaking tank containing fresh water for seven days. They were then removed and flaked in a machine specially designed to enable the lengths and thicknesses of the wood particles to be varied. After discharge from the flaking machine, the flakes were dried in a tray drier, from a moisture content of about 50 per cent to between 3 and 5 per cent.

Where a reduction in the width of the flakes was needed, they were passed through a

hammermill in which the screen size can be altered to obtain the width required. For example, flakes with an original width of ¾ to 1½ inches can be reduced to $^1/_{16}$ to ¼ inch wide particles, using a ½ inch screen, $^1/_{16}$ to ⅛ inch from a ⅜ inch screen, and so on.

Boardmaking

Particle boards of overall dimensions 14½″ x 14½″ x ¾″ and of density 40± 2 lb/cu.ft. were made by spraying a quantity of wood flakes in a rotary mixer with urea formaldehyde liquid resin containing 68 per cent of resin solids to which was added a hexamine/ammonium chloride hardener equivalent in weight to 10 per cent of the resin used.

A predetermined weight of the sprayed flakes was placed in a rectangular metal mould and after cold prepressing, the mould was removed and the mat placed in an electrically heated hydraulic press where it remained for 15 minutes under a pressure of 150 p.s.i., with platen temperature maintained at 140°C. Each finished sample board was subsequently cut into a number of test pieces and allowed to cure for seven days before being subjected to tests specified in BS No.2604: 1963.

During the preliminary stages of the investigation, boards were made from flakes of different dimensions from which the fines – i.e. that portion passing through a No.22 BS Sieve – were removed, whilst the weight of resin added to the flakes before pressing, remained constant at 8.0 per cent of the weight of dried flakes used. Later, using flakes of optimum dimensions to give maximum strength, the resin content was varied and boards were made from flakes from which the fines had been removed and also from unscreened flakes containing the fines. Wax emulsion was also added in some cases.

Board testing

The modulus of rupture (bending stress) was determined on test pieces 8 inches x 3 inches, supported on parallel metal rollers which were free to rotate on roller bearings. The distance between the rollers was 6 inches and the bending load was applied to the centre of the span.

To determine the tensile stress prependicular to the plane of the board, test pieces 1½ inches x 1½ inches were glued between two pieces of suitable wood, with the glue line on the top and bottom faces of the test piece. A tensile load was then applied to the sample until it failed.

To measure the resistance to the withdrawal of wood screws from particle board – i.e. screw-holding – test pieces 3 inches x 3 inches were prepared. Into each test piece, three 1½ inch long No.6 wood screws were inserted, one at the midpoint of a surface and one at each of two adjacent edges. The axial load required to withdraw each screw was then determined.

In all cases, the rate of loading was as specified by the British Standard.

Water absorption was measured by submerging test pieces, 8 inches x 3 inches, for one hour in water at a temperature of 18°C. The difference in weight before and after immersion, expressed as a percentage of the initial weight, is termed the water absorption. Thickness swelling is the increase in thickness of the 8 inches x 3 inches test pieces after submersion in water for one hour, expressed as a percentage of the initial thickness.

TEST RESULTS

Pinus brutia

Table 1 shows the results of the preliminary tests carried out on boards made from flakes of different dimensions. Using 8 per cent of resin, boards made from milled flakes between 0.6 and 1.6 inches long and 0.008 and 0.032 inches thick, all exceeded the BSS for modulus of rupture. Those boards made from unmilled flakes and those made from flakes milled through a ½ inch screen, have approximately the same modulus of rupture values. On the other hand, the mean value for those boards made from flakes milled through a ⅜ inch screen is a little lower. None of the boards made from unmilled flakes complied with the BSS for tensile strength perpendicular to plane. However, flakes milled through ½ inch and ⅜ inch screens met the BSS in this respect. Both screw holding properties and water absorption figures exceeded BSS for all boards made from this species. In general however, the best results were obtained from flakes milled to pass the ½ inch screen.

Table 2 shows the results of further tests carried out on boards made from flakes of *Pinus brutia* milled to constant width. The flakes prepared had lengths of 0.6, 0.8, 1.2 and 1.6 inches and thicknesses of 0.008, 0.016, 0.024 and 0.032 inches and were then milled to pass a half-inch screen.

With flake lengths of 0.6 and 0.8 inches, the modulus of rupture is at a maximum when the thickness of 0.008 or 0.024 inches. With the lengths of 1.2 and 1.6 inches however, the maximum occurs between thicknesses of 0.016 and 0.024 inches.

The effect of alterations in the length of flake when the thickness is kept constant is not so clearly defined; it would appear however, that within the limits of experimental error, the strength of the board remains about the same over the range of flake length from 0.6 to 1.6 inches for each of the flake thicknesses used. The water absorption and screw holding characteristics do not appear to be influenced to any great extent by changes in thickness or length of flake but there is some evidence that boards having the highest tensile stress are made from flakes 0.016 inches or 0.024 inches thick.

Pinus nigra

Table 3 shows two sets of results from tests carried out on boards made from *Pinus nigra*. In the first set, flakes of 1.2 inches length and 0.024 inches thickness were milled to pass a ½ inch screen. These were then mixed with three different proportions of resin with and without inclusion of the fines.

For the second set, these conditions were repeated with material milled through a ¾ inch screen instead of a ½ inch screen. In both cases there is very little difference between the strength of the boards as indicated by the modulus of rupture. Also, the width of the milled flakes, as indicated by the screen size, does not appear to have any appreciable effect on the board strength. Further, the board strength is almost unchanged for resin contents as low as 6.0 per cent and there is no significant difference in the tensile stress or in the screw holding strength. With the exception of the 8 per cent resin boards made from flakes milled to pass a ½ inch screen, the thickness swelling is considered to be a little high but still within the BSS but the water absorption in all cases complies with the BSS.

Acacia cyanophylla

Table 4 gives the results of tests carried out on boards made from *Acacia cyanophylla*. The flakes used were milled through ½ inch screen and kept at constant width, 1.2 inches long and 0.024 inches thick. Comparisons were made between boards containing 10 per cent of the fines and those from which fines were excluded. Resin contents of 9.0, 8.0, 7.0, 6.0 and 5.0 per cent were used and 1.0 per cent (by weight) of wax was added to some of the boards containing 8.0 per cent of resin. The presence of

10.0 per cent of fines has practically no effect on the modulus of rupture of the particle boards, nor does the presence of fines appreciably affect the tensile stress or the screw holding properties. With resin contents as low as 5.0 per cent, the modulus of rupture, tensile stress and screw holding are all within the BS specification but both the water absorption and thickness swelling are excessive. With a resin content of 9.0 per cent, the thickness swelling is still too high and it is not until 1.0 per cent of wax together with 8.0 per cent of resin is used that the boards comply with the BS requirements in this respect.

On the whole, this species does not produce very good boards.

Quercus alnifolia

Table 5 shows the results of the tests carried out on boards made from *Quercus alnifolia* using flakes of dimensions which gave the best results with the other species and with and without the inclusion of fines. As will be seen from the table of results, it was not possible to produce a board from this species having a modulus of rupture which complied with the BSS unless the density was increased to 55 lb cu.ft. All the other test parameters are within or at the BSS but in general, it is considered that this species does not make good particle boards.

Alnus orientalis

Table 6 shows the results of tests carried out on boards made from *Alnus orientalis* using flake dimensions as with the previous species. In each case, with and without the inclusion of fines, the modulus of rupture considerably exceeds the value shown in the BS specification. The tensile stress and screw holding values are also well within specification but the water absorption and thickness swelling are in most cases, too high and many are not within the specification. The addition of 1.0 per cent of wax does however produce a board with 8 per cent of resin which fulfils the requirements of the BS in all respects. Again this species cannot on the whole be considered a good board making material.

Eucalypt species

Tables 7 and 8 show the results of tests carried out on boards made from milled flakes (½" screen) of *E. gomphocephala* and *E.camaldulensis* respectively. For these tests 10.0 per cent of fines were included. It will be seen that with only one exception, the values specified in British Standards for the modulus of rupture, tensile strength and screw holding, were exceeded for both species. Without the addition of wax, water absorption and thickness swelling figures with both species fail to meet BSS. As will be seen from the table, the addition of wax to 8 per cent resin boards brings both species (with one comparatively small exception) to within the BSS.

Mixture of species

Table 9 shows the results of tests carried out on particle boards made from a mixture of equal weights of *Pinus brutia, Pinus nigra, Acacia cyanophylla* and *Alnus orientalis.* It also shows the results of similar tests in which the timbers used were mixed together in the same proportionate weights as we were advised would be available for boardmaking in Cyprus – i.e. 80 : 5 : 5 : 1.

Eucalyptus gomphocephala and *Eucalyptus camaldulensis* were not included in either of these mixtures because apparently none of this timber is available in Cyprus for boardmaking at the present moment.

Quercus alnifolia was also excluded because with this timber only high density

particle boards comply with British Standards.

As will be seen from the table, both mixtures produced boards which fulfilled the BS in strength characteristics but the addition of wax was required so that they would pass the standard for thickness swelling.

GENERAL CONCLUSIONS

1. The object of this investigation was to evaluate these seven species of Cyprus timber for their potential usefulness for the production of particle board. Throughout, it has been assumed that the definition of useful boardmaking material is one which will make a 40 lb per cu.ft. board with 8 per cent of synthetic resin binder (with up to 1 per cent of wax if required) having properties which fulfil the relevant BSS. The many reasons for adopting these board parameters are partly technical but mainly economic. Very briefly, the density has been fixed by industrial, technical and economic practice in developed countries as the optimum compromise between unpressed mat thickness, strength (this is proportional to density) and customer attraction. Strength can be increased by using more resin but the binder is the most expensive single component of a board. Industrial experience in developed countries indicates that the 8 per cent level is the best compromise between cost and board strength. It must be said that there is no reason why these considerations should not be modified for the needs of a developing country but they have been used as a reference level for comparison purposes with these seven species.

2. With this in mind, it is considered that both *Pinus brutia* and *Pinus nigra* would be in general, extremely good materials for particle board manufacture. In many respects they are fully up to the quality of the softwoods traditionally used in developed countries.

3. Of the other species, *Acacia cyanophylla, Alnus orientalis* and both Eucalypt species are only fairly good boardmaking materials. Perhaps their worst failing is the tendency for boards made from them to be unduly affected by moisture.

4. *Quercus alnifolia* is the worst of the seven. On the whole its use alone for boardmaking cannot be recommended.

5. With the boards made from a mixture of species (with the exclusions referred to in the report) it would appear that the two pines are 'carrying' the other less suitable species. Nevertheless, these mixed species boards are acceptable and might prove useful for the production of cheaper and weaker core-boards destined for subsequent facing or lamination.

Tables

Table 1
Pinus brutia
Resin content 8.0 per cent: fines excluded

Flake dimensions ins. Width	Length	Thickness	Density lb./cu.ft.	Modulus of Rupture p.s.i.	Tensile Stress Parpendicular to plane p.s.i.	Screw Holding lbs.	Water Absorption per cent
0.75 – 1.50	0.6	0.008	39.9	2800	48	132	55
	0.8	0.016	41.7	2820	33	144	45
	1.2	0.024	41.5	3680	43	145	50
	1.6	0.032	41.8	3290	21	176	38
0.06 – 0.25	0.6	0.008	41.6	3450	97	212	40
(Through ½ in)	0.8	0.016	40.2	2720	70	212	40
screen	1.2	0.024	41.2	3340	134	228	53
	1.6	0.032	40.4	2700	88	216	26
0.06 – 0.12	0.6	0.008	40.8	3240	109	197	40
(Through ⅜ in)	0.8	0.016	40.8	2460	88	199	28
screen	1.2	0.024	40.4	3060	116	215	42
	1.6	0.032	40.3	1680	84	208	57
BS 2604: 1963				2000	50	80	75

Table 2
Pinus brutia
Flakes milled through ½ inch screen : fines excluded: resin content 8.0 per cent

Flake Dimensions ins. Length	Thickness	Density lb.cu.ft.	Modulus of Rupture p.s.i.	Tensile Stress Perpendicular to plane p.s.i.	Screw Holding lbs.	Water Absorption per cent
0.6	0.008	41.6	3450	97	212	40
	0.016	40.5	2680	100	174	60
	0.024	41.9	3270	101	203	74
	0.032	39.5	2850	117	210	48
0.8	0.008	40.7	3240	80	170	31
	0.016	40.2	2720	70	212	40
	0.024	40.6	3390	152	207	61
	0.032	40.9	2610	140	210	54
1.2	0.008	41.2	2960	73	209	67
	0.016	41.9	3380	152	198	48
	0.024	41.2	3340	134	228	53
	0.032	40.5	3010	126	231	60
1.6	0.008	40.5	2860	100	186	44
	0.016	39.9	3230	133	186	50
	0.024	40.0	3110	139	188	53
	0.032	40.4	2700	88	216	36
BS 2604: 1963			2000	50	80	75

Table 3
Pinus nigra
Flake dimensions — length 1.2 in., thickness 0.024 in., milled through ½ in. and ¾ in. screen. Resin content varied: fines included and excluded.

Screen Size ins.	Resin content per cent	Fines content per cent	Density lb./cu.ft.	Modulus of Rupture p.s.i.	Tensile Stress perpendicular to plane p.s.i.	Screw Holding lbs.	Water absorption per cent	Thickness swelling per cent
½	8.0	9.0	39.7	2250	152	183	51	11.6
		Nil	41.1	2240	107	186	57	12.2
	7.0	9.0	41.2	2060	113	190	64	17.5
		Nil	40.6	2215	152	197	55	12.3
	6.0	9.0	41.6	2200	173	177	66	16.3
		Nil	40.6	2105	144	150	66	22.4
¾	8.0	9.0	41.3	2140	95	191	53	13.4
		Nil	40.6	2100	108	214	51	13.9
	7.0	9.0	41.5	2415	139	185	59	15.0
		Nil	40.0	1980	117	176	54	14.7
	6.0	9.0	41.4	2380	172	172	60	15.8
		Nil	40.9	2180	173	189	50	15.7
BS 2604: 1963				2000	50	80	75	12.0

Table 4
Acacia cyanophylla
Flake dimensions — length 1.2 in., thickness 0.024 in., width 0.06 — 0.05 in. (through ½ in. screen)
Resin content varied: fines included and excluded.

Resin Content per cent	Fines Content per cent	Density lb./cu.ft.	Modulus of Rupture p.s.i.	Tensile Stress perpendicular to plane p.s.i.	Screw Holding lbs.	Water Absorption per cent	Thickness Swelling per cent
9.0	10.0	40.2	3000	170	227	54	17.4
	Nil	40.6	3190	152	233	60	18.8
8.0	10.0	40.9	2840	103	210	61	18.5
	Nil	41.2	2650	117	204	70	24.5
7.0	10.0	40.4	2495	119	193	68	24.5
	Nil	40.7	2575	119	189	70	27.0
6.0	10.0	40.1	2400	140	193	66	23.0
	Nil	40.9	2755	139	190	68	26.5
5.0	10.0	40.4	2350	93	213	73	31.3
	Nil	41.6	2765	99	215	75	34.0
8.0 +1.0% wax	Nil	41.6	3300	147	246	22	12.1
BS. 2604: 1963			2000	50	80	75	12.0

Table 5
Quercus alnifolia
Flake dimensions — length 1.2 in., thickness 0.024 in., width 0.06 — 0.05 in. (through ½ in. screen)
Resin content varied: fines included and excluded.

Resin Content per cent	Fines Content per cent	Density lb./cu.ft.	Modulus of Rupture p.s.i.	Tensile Stress perpendicular to plane p.s.i.	Screw Holding lbs.	Water Absorption per cent	Thickness Swelling per cent
10.0	10.0	41.2	1591	102	140	75	18.1
	Nil	40.0	1537	91	131	66	19.1
9.0	10.0	40.2	1532	74	151	71	18.7
	Nil	40.0	1676	95	145	64	17.2
8.0	10.0	40.5	1682	115	106	63	15.5
	Nil	41.1	1738	104	110	69	18.3
7.0	10.0	40.0	1414	119	95	65	16.9
	Nil	39.9	1404	100	108	74	21.8
6.0	10.0	39.2	1427	105	90	71	18.5
	Nil	40.5	1581	100	101	69	21.8
8.0	10.0	55.4	4158	189	384	38	19.8
8.0 + 1.0% wax	10.0	55.3	3688	184	300	34	22.8
BS. 2604: 1963			2000	50	80	75	12.0

Table 6
Alnus orientalis
Flake dimensions – length 1.2 in., thickness 0.024 in., width 0.06 – 0.25 in. (through ½ in. screen). Resin content varied : wax included and excluded, fines included and excluded.

Resin Content per cent	Fines Content per cent	Density lb./cu.ft.	Modulus of rupture p.s.i.	Tensile stress perpendicular to plane p.s.i.	Screw Holding lbs.	Water Absorption per cent	Thickness Swelling per cent
8.0	10.0	40.6	3073	138	226	68	23
	Nil	40.7	3169	158	226	76	24.4
7.0	10.0	41.2	2973	134	244	71	19.7
	Nil	40.6	3423	149	219	67	27.6
6.0	10.0	40.8	2905	113	219	73	30.1
	Nil	40.6	2901	101	203	82	34.7
8.0 + 1% wax	Nil	40.3	3399	143	239	19	9.7
3.0 + 1% wax	Nil	40.0	1873	62	112	10	6.6
BS 2604 : 1963			2000	50	80	75	12.0

Table 7
Eucalyptus gomphocephala
Flake dimensions – length 1.2 in., thickness 0.024 in., width 0.06 – 0.25 in. (through ½ in. screen). Resin content varied : wax included and excluded, 10.0 per cent fines included.

Resin Content per cent	Density lb./cu.ft.	Modulus of rupture p.s.i.	Tensile Stress perpendicular to plane p.s.i.	Screw Holding lbs.	Water Absorption per cent	Thickness Swelling per cent
8.0	40.5	2095	81	143	77	21.7
7.0	40.8	2043	96	127	85	24.2
6.0	40.5	1771	64	119	95	30.1
8.0 + 1% wax	40.6	2501	116	161	39	17.5
BS 2604 : 1963		2000	50	80	75	12.0

Table 8
Eucalyptus camaldulensis
Flake dimensions – length 1.2 in., thickness 0.024 in., width 0.06 - 0.25 in., (through ½ in. screen). Resin content varied : 10.0 per cent fines included.

Resin Content per cent	Density lb./cu.ft.	Modulus of rupture p.s.i.	Tensile Stress perpendicular to plane p.s.i.	Screw Holding lbs.	Water Absorption per cent	Thickness Swelling per cent
8.0	41.2	2305	95	171	83	30.2
7.0	41.5	2387	92	163	85	32.5
6.0	41.3	2099	108	172	84	33.5
8.0 + 1% wax	40.5	2709	158	198	9	5.1
BS 2604 : 1963		2000	50	80	75	12.0

Table 9

Mixture of Species

Flake dimensions – length 1.2 in., thickness 0.024 in., width 0.06 – 0.25 in.(through ½ in. screen). Resin content 8.0 per cent, with and without wax : 10.0 per cent fines included.

Proportion* by weight of species	Resin Content per cent	Density lb./cu.ft.	Modulus of rupture p.s.i.	Tensile Stress perpendicular to plane p.s.i.	Screw Holding lbs.	Water Absorption per cent	Thickness Swelling per cent
1 : 1 : 1 : 1	8.0	41.2	3103	114	240	69	16.7
	8.0 + 1.0 wax	40.6	3073	141	237	9	4.1
80 : 5 : 5 : 1	8.0	40.7	2714	121	187	46	15.0
	8.0 + 1.0 wax	40.5	2464	95	183	13	5.3
BS 2604 : 1963			2000	50	80	75	12.0

**Pinus brutia : Pinus nigra : Acacia cyanophylla : Alnus orientalis*

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